Terrestrial ecosystems, increased solar ultraviolet radiation, and interactions with other climate change factors

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Abstract:

There have been significant advances in our understanding of the effects of UV-B radiation on terrestrial ecosystems, especially in the description of mechanisms of plant response. A further area of highly interesting research emphasizes the importance of indirect UV radiation effects on plants, pathogens, herbivores, soil microbes and ecosystem processes below the surface. Although photosynthesis of higher plants and mosses is seldom affected by enhanced or reduced UV-B radiation in most field studies, effects on growth and morphology (form) of higher plants and mosses are often manifested. This can lead to small reductions in shoot production and changes in the competitive balance of different species. Fungi and bacteria are generally more sensitive to damage by UV-B radiation than are higher plants. However, the species differ in their UV-B radiation sensitivity to damage, some being affected while others may be very tolerant. This can lead to changes in species composition of microbial communities with subsequent influences on processes such as litter decomposition. Changes in plant chemical composition are commonly reported due to UV-B manipulations (either enhancement or attenuation of UV-B in sunlight) and may lead to substantial reductions in consumption of plant tissues by insects. Although sunlight does not penetrate significantly into soils, the biomass and morphology of plant root systems of plants can be modified to a much greater degree than plant shoots. Root mass can exhibit sizeable declines with more UV-B. Also, UV-B-induced changes in soil microbial communities and biomass, as well as altered populations of small invertebrates have been reported and these changes have important implications for mineral nutrient cycling in the soil. Many new developments in understanding the underlying mechanisms mediating plant response to UV-B radiation have emerged. This new information is helpful in understanding common responses of plants to UV-B radiation, such as diminished growth, acclimation responses of plants to UV-B radiation and interactions of plants with consumer organisms such as insects and plant pathogens. The response to UV-B radiation involves both the initial stimulus by solar radiation and transmission of signals within the plants. Resulting changes in gene expression induced by these signals may have elements in common with those elicited by other environmental factors, and generate overlapping functional (including acclimation) responses. Concurrent responses of terrestrial systems to the combination of enhanced UV-B radiation and other global change factors (increased temperature, CO2, available nitrogen and altered precipitation) are less well understood. Studies of individual plant responses to combinations of factors indicate that plant growth can be augmented by higher CO2 levels, yet many of the effects of UV-B radiation are usually not ameliorated by the elevated CO2. UV-B radiation often increases both plant frost tolerance and survival under extreme high temperature conditions. Conversely, extreme temperatures sometimes influence the UV-B radiation sensitivity of plants directly. Plants that endure water deficit stress

effectively are also likely to be tolerant of high UV-B flux. Biologically available nitrogen is exceeding historical levels in many regions due to human activities. Studies show that plants well supplied with nitrogen are generally more sensitive to UV-B radiation. Technical issues concerning the use of biological spectral weighting functions (BSWFs) have been further elucidated. The BSWFs, which are multiplication factors assigned to different wavelengths giving an indication of their relative biological effectiveness, are critical to the proper conduct and interpretation of experiments in which organisms are exposed to UV radiation, both in the field and in controlled environment facilities. The characteristics of BSWFs vary considerably among different plant processes, such as growth, DNA damage, oxidative damage and induction of changes in secondary chemicals. Thus, use of a single BSWF for plant or ecosystem response is not appropriate. This brief review emphasizes progress since the previous report toward the understanding of solar ultraviolet radiation effects on terrestrial systems as it relates to ozone column reduction and the interaction of climate change factors.

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Resource Description

Exposure :

weather or climate related pathway by which climate change affects health

Ecosystem Changes, Extreme Weather Event, Precipitation, Solar Radiation, Unspecified Exposure

Extreme Weather Event: Drought

Geographic Feature:

resource focuses on specific type of geography

None or Unspecified

Geographic Location:

resource focuses on specific location

Global or Unspecified

Health Impact:

specification of health effect or disease related to climate change exposure

Health Outcome Unspecified

Resource Type:

format or standard characteristic of resource

Review

Resilience:

capacity of an individual, community, or institution to dynamically and effectively respond or adapt to shifting climate impact circumstances while continuing to function

A focus of content

Timescale:

time period studied

Time Scale Unspecified